EGU22-5979
https://doi.org/10.5194/egusphere-egu22-5979
EGU General Assembly 2022

Quartz grain fabric in shales and sandstones: Some contrasting behaviors

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Many processes are at work when a sedimentary rock deforms. Quartz grains, for example, can rotate rigidly in the matrix, or on the contrary, undergo processes of dissolution and crystallization. Microtomography allows us to image the 3D geometry of minerals at the micron scale and quantify their fabric. Here, we use the quartz shape fabric extracted from microtomography data to evaluate the mechanisms active during burial and deformation of several sedimentary rocks systems.

Our first examples are of shales developing a slaty cleavage oblique to bedding. For shales that have undergone moderate burial (T_{burial} max ~200°C) (Sigues locality, Pyrenees), we show that the quartz grains rotate very little in the clay matrix. Even with the development of a slaty cleavage, a significant proportion of quartz grains remain parallel to the bedding plane. This surprising result implies that the rigid rotation of quartz grains, even in a ductile clay matrix, is not effective.

In shales having undergone deeper burial and temperatures approaching the lower greenschist facies (T_{burial} max ~280°C) (Lehigh Gap locality, Appalachian mountains), we show that the average short-axis of the grains is orthogonal to the cleavage plane. We suggest that this shape preferred orientation results from preferential dissolution of quartz faces oriented perpendicular to sigma 1, thus resulting in a shape preferred orientation without significant grain rotation.

Our last example concerns fine-grained sandstones, slightly deformed and buried at a shallow depth. If we refer to the example of shales with little burial, we would expect a very strong control of the bedding on the quartz fabric, since at these P-T conditions we expected dissolution-precipitation processes to be sluggish, and grain rotation to be ineffective. However, surprisingly, the quartz in this rock is well oriented in the fabric which is oriented perpendicular to the bedding.

How the quartz grains were reoriented in the fine-grained sandstone suggests relations still not well understood with the deformation of a porous rock and the cementing processes of the rock. The microtomography approach in fine-grained rocks opens a door to this understanding of the behavior of quartz grains in sedimentary rocks.